The Missing Revolution

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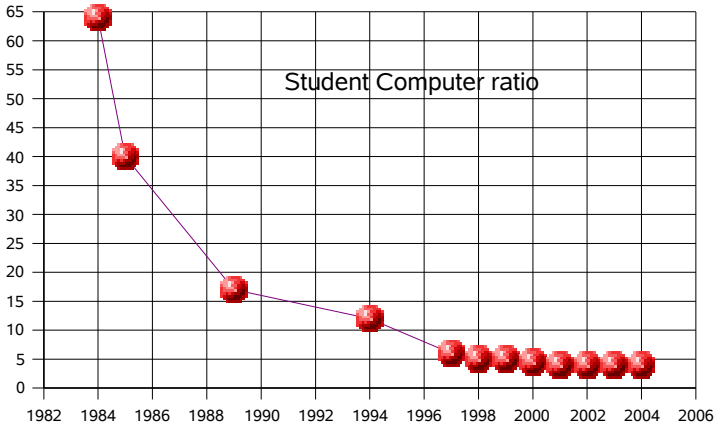
I first entered the world of microprocessor-based personal computing for education in the late 1970's. In those days, the dominant players were Commodore, Radio Shack, and Apple. Computer software was often written by teachers themselves and either given away, or sold for reproduction costs on tape cassettes. Over the following years, educational computing came to be increasingly popular, and the number of computers soon reached the level of one per school, with the next goal being one computer per classroom. Today, with sharply reduced prices for hardware, we talk about one computer per student as a goal.

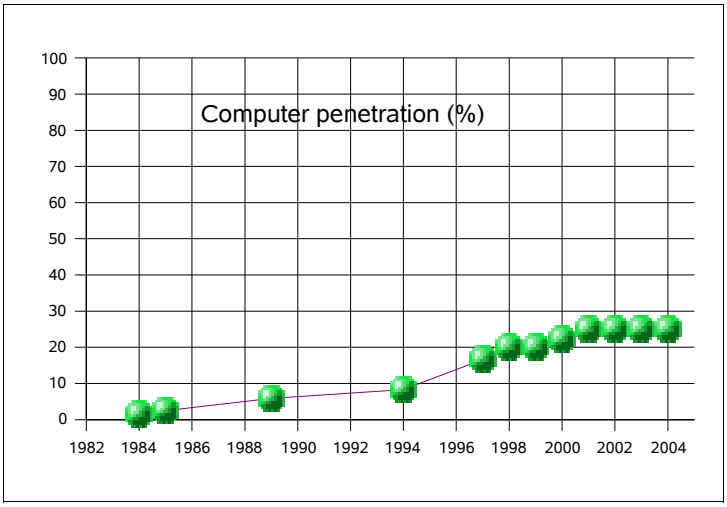
One-to-one computing promises to promote a revolution in teaching and learning, but while the two goals of bringing computers to schools and then classrooms were achieved fairly quickly, the move to one-to-one computer access has been much harder to achieve. Even so, there are those who claim we are on the path to universal access, and use charts like the following to show how much progress has been made in bringing computers into schools.



This graph of student-computer ratio (based on data from the National Center for Educational Statistics) is impressive at first glance. From a ratio of sixty-five students per computer as recently as 1984, the curve shows a steep decline to the present ratio of four students per computer. The challenge presented by this data is not apparent when plotted in this fashion, and one can be forgiven for thinking that we are continuing to make progress toward universal access when, in fact, this is not even remotely the case in US schools.

To see why, let's plot the same data a bit differently. Instead of plotting student computer ratio, let's invert the dataset and look at the percentage of students who (at any given moment) have access to technology in their schools.

This graph tells a compelling story. Over the past four years, computer penetration in US classrooms has leveled off at 25% (on a per student basis), and shows no sign of changing. This means, if Juan is using the computer, then Maria, George and Phyllis are not. With penetration this low, how could we possibly think that computers have a transformative impact on education?



Schools are, in fact, buying computers every year. Where are they going? New technology purchases by schools have largely been devoted to replacing outdated or broken equipment, leaving 75% of the goal unachieved. Budget cuts at all levels of government have contributed to the problem, making it seem that we will never be able to fill in the gap. As we'll see later, there are some steps that can be taken to help, however, even in the face of declining budgets.

For the richest nation on the planet, this is bizarre. The case for educational technology as an effective tool for learning is generally accepted. If we know these tools have value to learners, then we need to ask why we only reach 25% of our students at any given time. (Note: visits to actual classrooms confirm that many of them have little or no access to computers, so this graph only represents the national average.)

There have been research projects in many school systems devoted to one-to-one computing, and (depending on the design of the programs) some of these efforts have been more successful than others. These projects, though, are so small that their number barely affects the national average.

We talk about the educational computing "revolution" as if we have achieved something of great significance in the use of these tools to transform pedagogical practice. In fact, with a computer penetration this low, teachers can well be forgiven for continuing to teach in the same ways they did pre-computers. If only some have access at any given time, the chance to use technology to implement

different models of classroom practice is blocked.

Suppose we grant the possibility that computers connected to the broadband internet can be powerful tools in the hands of students (something I believe), then we should ask why we haven't made more progress, and, more to the point, why our progress has been brought to a standstill. In addressing this issue, I want to distinguish between universal access and one-to-one computing where each student has a laptop that affords true anywhere/anytime access to resources. I believe strongly that the one-to-one solution is the preferable approach, long term, but acknowledge that any solution that brings universal access is worth exploring. In other words, it is the educational value of access that is most important, not the specific form that access takes.

Why did the revolution stall?

This question has several answers. The one that gets the most attention is cost. Technology proponents are often shut down by presumed budgetary considerations. "Yes, this is all a good idea, but we can't afford to spend $400 per student (for example) for a dedicated computer." Statements like this are commonly made by the same people who gladly spend $75 per textbook in each of several content areas per student – resulting in a per-student total that rivals that of a powerful computer with broadband access to the Internet.

One response to this criticism is to suggest that, if we didn't purchase traditional textbooks (or bought fewer of them), we might well be able to afford computers for every child. Buried in this "cost" criticism is a greater barrier – the presumed shift from a teacher-centric toward a student-directed model of learning. Textbooks support existing hierarchical full-frontal teaching models with an emphasis on the delivery of a specified curriculum measured by standardized examinations. The fear that students might go off and explore aspects of a topic in new or innovative ways (and thus miss a few factoids for the next test) is enough to make some educational establishments steer away from universal access, or to co-opt one-to-one programs in support of older pedagogical models that scarcely address the learning needs of 21st century students. The attachment to old models shows up when teachers complain that students are "on the computer" while they are giving a lecture. This criticism of universal access is important. There will remain a place for some traditional presentations of content in some subjects. That said, effective staff development can help teachers understand the various modes of student engagement with subject matter, and how to gain student attention for some teacher-directed content.

Another criticism of universal access is related to cost in a (comparatively) mundane area – many schools lack the electric power in each classroom to run 30 computers at a time (along with a projector, printer, and interactive whiteboard.) Furthermore, student desks are generally not designed to hold computers, and are often too high for students to easily use a laptop keyboard. New furniture is expensive, and needs to be considered as part of a capital investment in schools serious about universal access. The good news is that these are largely one-time expenses. If universal access is phased in over time (say five classrooms per school per year as proposed in Indiana), these costs can be spread out to make the budget easier to balance.

Suppose, though, you have faculties more than ready to embrace universal access, and also have the electricity and communications infrastructure to implement the vision. There is still another objection that needs to be addressed: the ongoing cost of the technology itself.

You don't need to be a student of Moore's Law to know that computer power skyrockets every year, while hardware prices continue to drop like a rock. A quick run to Sam's Club (like the one I made a few days ago) showed that you can get a two-gigahertz laptop with a good-sized hard drive and built-in wireless access for about $400 in quantities of one. By the weekend a glance at the newspaper ads showed an even better offer:

Under $300 for a new laptop plus a printer! Yes, this was a limited offer, probably selling at cost just to bring people to the store, but imagine what you'd pay if you ordered these by the thousands (or millions)! It is pretty clear that the barrier to universal access is not the hardware expense. Even if the hardware is upgraded every three years, given the trend in computer pricing, the replacement costs will be a fraction of what you'd pay today.

But while it is true that hardware costs will continue to drop while the performance improves, the same can not be said for software. While some providers of proprietary software bend over backwards to make their licenses affordable to schools, other vendors establish annual license fees that can make universal access virtually impossible to achieve.

Depending on the State, for example, Microsoft charges an annual license for Windows XP and Microsoft Office that can range to over $100 per year, per computer. Even if the hardware was free, a state with a million students would find themselves strapped with an annual software license of $100 Million, and this is just for the operating system and commodity software. Curriculum specific software or other tools geared specifically for education have to compete for software money being spent just to allow the computers to be legally turned on.

Clearly, it is the right of any vendor to set and charge any price they wish for their software. The marketplace will determine if the price-point is acceptable. If, however, you are interested in finding ways to afford universal student access to powerful computing, you need to think about alternatives that can save significant amounts of money.

Linux on the student desktop

Fortunately, there is a solution to this challenge that can make software affordable even as the number of computers grows to fill in the remaining 75% gap in our schools: putting Linux on student desktops.

Linux is a UNIX-like operating system that runs on microprocessor-based personal computers. The normal operating systems on these machines today are Windows XP and the Mac OS X. Like these, Linux allows computers to run software, access networks, communicate with other devices, and otherwise make it possible for your computer to do interesting things. While the original motivation for creating Linux was to bring a "serious" operating system to the personal computer, the Linux movement has grown to the point where it is fast becoming the dominant operating system for many applications.

Linus Torvalds, the originator of Linux, was a college student who first envisioned this as a project for his own use. He decided to make the source code of Linux available to the public at large which had two effects. First, it built a community of Linux users capable of fixing errors in the operating system, and adding new features over time. Second, it insured that, as new computers and peripherals came on the market, Linux would be upgraded to run on just about any computer platform imaginable (including, for example, the iPod if you want).

Because it is based on UNIX, Linux is powerful, fast and reliable. Cray, for example, uses Linux as the operating system for the Red Storm supercomputer at Sandia Labs. Several US telephone companies use Linux-based computers to manage telephone connections. Many of the commercial Internet service providers use Linux-based servers. Speed and reliability are critical in all these applications.

For years, Linux was largely relegated to the "back office," where highly-technical folks accessed their Linux systems with text-based terminal programs reminiscent of the old days of Microsoft DOS. The casual user was generally too intimidated by the cryptic commands needed to install and launch software to take Linux seriously, so only a small number of dedicated users worked with this OS outside of specialized environments.

Recently, Linux distributions (distros) for ordinary computer users have been created that have a nice graphical user interface similar to those found on Windows XP or Mac OS X. When using one of these flavors of Linux, the learning curve for new users is amazingly short, as long as the user is already familiar with the Windows or Macintosh operating system. The skills acquired in one system transfer to Linux just fine.

One of the most popular desktop implementations of Linux today is Ubuntu (www.ubuntu.com) which uses an elegant graphical user interface. Ubuntu is not alone, and new Linux distros are entering the marketplace every day. To get a sense of how many versions of Linux are in common use today, visit DistroWatch (www.distrowatch.com).

The reason that Linux has been able to migrate and morph into different powerful versions is that the underlying programs are free to be examined, modified, and redistributed as the user wants. While there is a clearinghouse to insure that the Linux core remains stable, variations based on user interfaces, and accompanying software, proliferate.

This quality of Linux is important. Unlike Windows or the Mac OS which are "single source" closed operating systems, Linux users are free to choose the version that best meets their needs. This is important for school districts concerned about local control. There is no local control when using the Microsoft or Apple operating system. The ability to choose from over a hundred Linux distributions brings true choice to educational computing for the first time. Of course this amount of choice can be intimidating. Because of this, it is a good idea for a State or district to pre-screen various distros and prepare a list of recommended versions with enough background information to let schools make an informed choice. While the look and feel of different distros may vary, they are all capable of running the same applications, so the critical issues have to do with maintenance and ease of use.

Another advantage of Linux is that many distros are available for free. For example, Edubuntu (www.edubuntu.org) is an educational version of Ubuntu for K-12 users. It includes a nice user interface and a large library of open source software applications for K-12 users, all available at no cost whatsoever. A State with a million students could see their annual core software subscriptions fall from $100 Million to zero just by changing to this operating system.

What about the software?

If you are new to Linux, you might well be asking, what about the software? Does Linux run Microsoft Office? Inspiration? the iLife suite? Does it run specialized educational software? What about Photoshop?

The answer is that, as of this moment, most common educational titles are not shipping in versions that run under Linux. That said, there are two things you need to consider. First, in many cases, there are free open-source equivalents of commercial software, some of which are even more powerful than their proprietary counterparts. For example, OpenOffice (www.openoffice.org) performs the functions of Microsoft Office, even to the level of being able to import and export documents in the Microsoft format if you need to. Beyond providing this base functionality, OpenOffice also adds new features, including the ability to export a presentation as a Flash object for posting on the web, for example. And, OpenOffice is free. The GIMP performs many of the same functions as Adobe Photoshop, and is also free. The list goes on and on. The quest for powerful open source software was one of the reasons I wrote the book *When the*

Best is Free which describes several powerful programs that run well on Linux (and other operating systems, for that matter).

Because the number of free open-source titles for Linux is growing, the pressure is on for proprietary software vendors to create Linux versions so they can sell into this growing market before someone creates similar functionality and gives it away. Stagecast Creator (www.stagecast.com) and Visual Thesaurus (www.visualthesaurus.com) are just two examples of commercial software used in education that can run under Linux (as well as the Mac and Windows operating systems), and many more are on their way. The easiest way to get even more software converted is for schools and districts to contact the software publishers themselves and tell them that continued purchases will be based on their willingness to support Linux.

This is exactly what vendors have done in the past whenever Apple or Microsoft introduced a new operating system. Keeping up with operating systems is the price of admission for software vendors. That said, there are exceptions. Apple has little interest in porting their iLife suite to any other operating system since they use this software to help drive hardware sales. Other vendors only support one operating system because they lack the resources or interest to port their work to other systems. The reality in education, however, is that successful software vendors need to have their software work on whatever computers schools have. The software experience needs to transcend hardware decisions whenever possible.

What future is there for commercial software when open-source software becomes more popular? The reality is that free software has always co-existed with commercial proprietary titles. People will gladly pay for quality and, if they don't have to pay for the operating system or commodity software, this leaves more money for specialized software. The open-source movement actually benefits several constituencies:

- Hardware vendors can start to tap the 75% growth opportunity as scarce funds get redistributed,
- Subscription services (e.g., Safari, Nettrekker) can reach more classrooms,
- Students gain the kind of technology access needed to develop and grow the skills needed to thrive in 21st century,
- Teachers get the technology support needed to teach in new ways.

The true beneficiaries are the creative fast-movers both inside and outside the classroom.

The hidden cost

So far we've explored the continued drop in the price of computer hardware, and showed how a powerful operating system and large libraries of commodity software can be obtained for free. There is one other cost factor that has not been mentioned – a cost that is inescapable. While it is true that a modern Linux implementation can be mastered by any current computer user in a short period of time, staff development is needed to help educators build the pedagogical bridge to learning in the environment of universal access. Unless many pre-service institutions change their practice, it is unlikely that they will be able to offer much help in this regard, which means that even the newest teachers will need assistance in learning how to help students achieve mastery with the aid of ubiquitous computing. Keep in mind that we all bring our personal experiences into the classroom, so if teachers lack the background in teaching with technology, teachers won't be able to transfer this enthusiasm to the students.

While traditional face-to-face staff development will always have its place, much of it can be supplemented with on-line activities where teachers and educational leaders get to acquire new skills using the same tools their students have. This investment needs to be thought of in a broad context. If each teacher impacts the lives of thirty to 150 students per year, and teaches for two to three decades, the impact of effective, ongoing, and well-supported staff development gets multiplied by the benefit it brings to 600 to thousands of students over the career of each teacher.

As I've said for many years, in the absence of powerful transformative staff development, the dominant impact of technology in the classroom is likely to be an increase in the electric bill.

Yes, the promised computer revolution in education is missing. We have only achieved 25% of the goal; but the remaining 75% is achievable if we are willing to take advantage of the heroic efforts of those creative people who have dedicated themselves to making computing accessible to anyone, anytime. To make this happen, alliances are essential. Everyone related to education needs to be committed to the vision and to making it happen. We need to support student learning by any means possible as part of a global community.

The Ubuntu distro of Linux takes its name from an old Bantu word which means, "I am who I am because of who we all are." All of us, pulling together, can help every student in the country be all she or he can be. Let's unleash this power, and let's unleash it now.

About the author

Dr. David Thornburg is founder and Director of Global Operations for the Thornburg Center, an international consulting firm specializing in K-12 education and the role technology can play in support of student learning. Prior to founding the Thornburg Center in 1980, Dr. Thornburg was a Principal Scientist at the Xerox Palo Alto Research Center where, among other things, he invented user interface technologies for personal computers still in use today.

Dr. Thornburg is an active proponent of Linux and open-source software in general. His book on open-source software for all computer platforms, *When the Best is Free*, has received accolades. For more information on this book and other topics relating to this briefing, visit www.tcpdpodcast.org. David gives presentations on topics related to educational technology throughout the world, and is often on the programs of major educational technology conferences in the US. His pedagogical interests lie in the constructivist domain of inquiry-driven project-based learning, and he believes that technology needs to be applied in ways that honor the integrity and capacity of every child as a lifelong learner.